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OUTLET PLUNGE POOL AND FISHWAY APPROACH ELK CREEK DAM, ROGUE RI--ETC(U)
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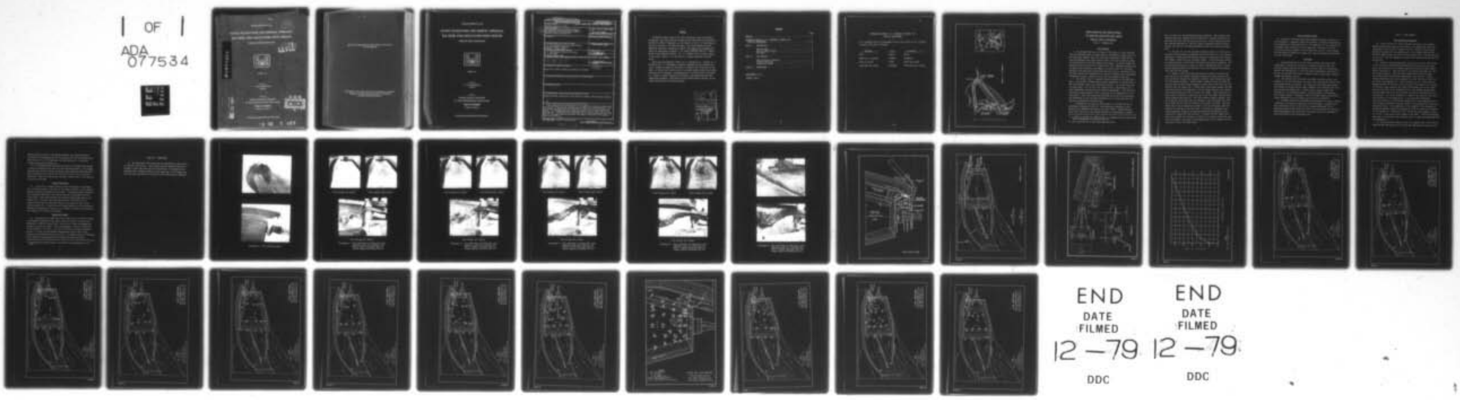

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TECHNICAL REPORT NO. 164-1

OUTLET PLUNGE POOL AND FISHWAY APPROACH, ELK CREEK DAM, ROGUE RIVER BASIN, OREGON

HYDRAULIC MODEL INVESTIGATION

LEVEL II

OCTOBER 1979

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Flow conditions in the plunge pool of the regulating outlet flip bucket and the adjacent fishway approach channel were studied in a 1:40-scale model. The flip bucket and plunge pool were satisfactory and would be an effective fish barrier. The fishway approach channel and entrance on the right bank were not satisfactory. Preliminary tests indicated that a fishway entrance at the right edge of the plunge area and attraction flow leads in the base of the bucket would be effective.

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PREFACE

A hydraulic model study of Elk Creek regulating outlet flip bucket, plunge pool, and fish attraction conditions was authorized 30 July 1974 by the Office, Chief of Engineers, at the request of the U. S. Army Engineer District, Portland. The study was made at the North Pacific Division Hydraulic Laboratory, Bonneville, Oregon, from August 1974 to March 1975 under the supervision of Messrs. P. M. Smith, Director, and A. J. Chanda, Chief of the Hydraulics Branch. Mr. T. D. Edmister was in direct charge of the study. Messrs. D. E. Fox and R. W. Parker conducted the model tests.

During the investigation, Messrs. H. P. Tervooren, D. J. Sparks, R. L. Davidson, and R. A. Wellington, hydraulic engineers of the Portland District, visited the Hydraulic Laboratory to observe flow conditions in the model, to discuss test results, and to correlate those results with design work that was in progress. Representatives of the North Pacific Division, U. S. Bureau of Sport Fisheries and Wildlife, and Oregon Fish and Game Commissions attended a conference and model demonstration relative to the outlet works and fish collection system.

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CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
miles (U. S. statute)	1.609344	kilometres
feet per second	0.3048	metres per second
cubic feet per second	0.0283168	cubic metres per second

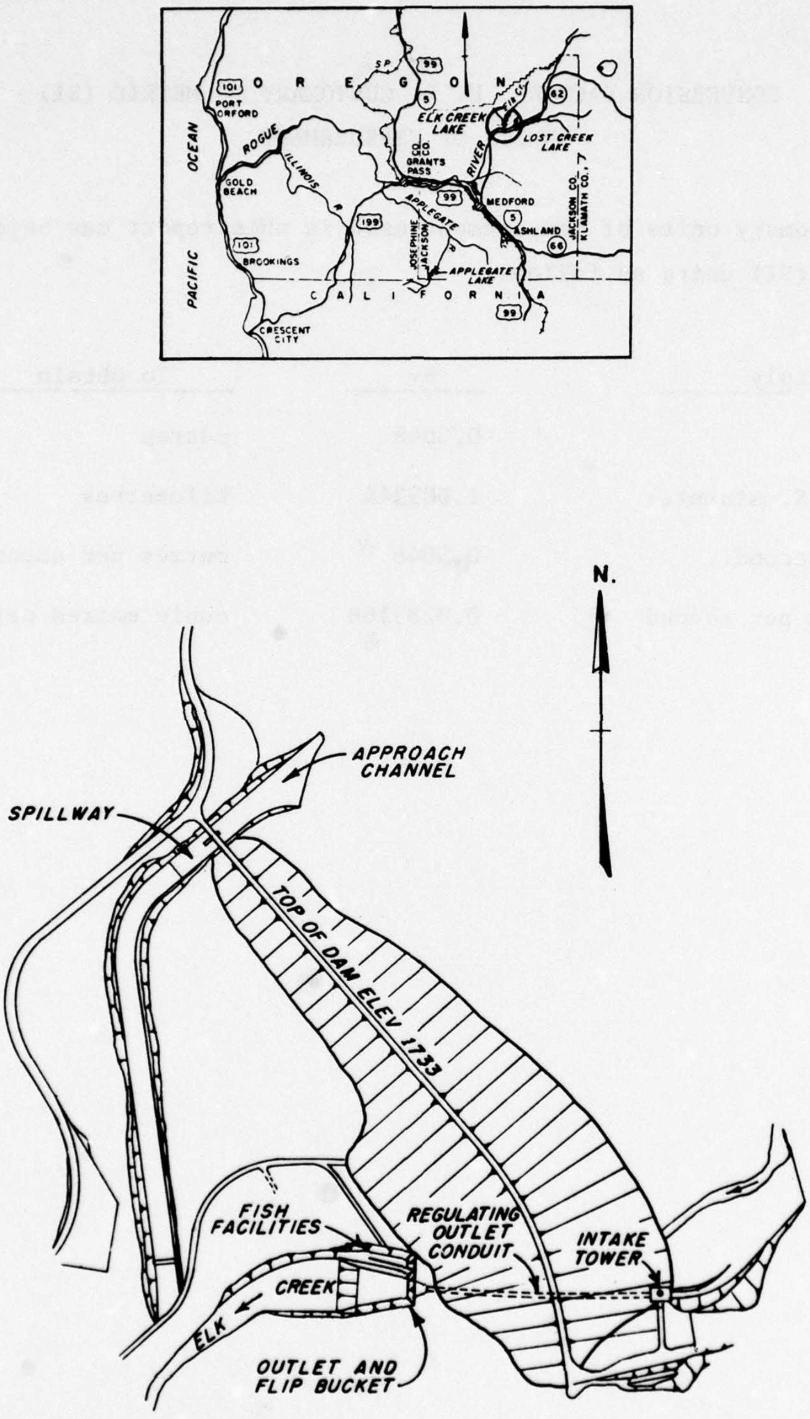

Fig. 1. Vicinity map and project layout

OUTLET PLUNGE POOL AND FISHWAY APPROACH

ELK CREEK DAM, ROGUE RIVER BASIN, OREGON

Hydraulic Model Investigation

PART I: INTRODUCTION

The Prototype

1. The proposed dam site is located on Elk Creek 1.7 miles upstream from the confluence with the Rogue River in southwestern Oregon (fig. 1).* Elk Creek Dam, together with Lost Creek Dam (completed in 1976) and the proposed Applegate Dam, would control runoff to prevent disastrous winter and spring floods in the Lower Rogue River Valley. During the summer the projects would release water to support fish life, replenish municipal and irrigation water supplies, and enhance the scenic beauty and ecological balance of the Rogue River downstream from the projects. Approval of the Elk Creek project was withdrawn by the State of Oregon until environmental problems are solved. Design of the project was stopped in May 1975.

2. The project (fig. 1) included a gated spillway in the right abutment, a 238-ft-high, 2,560-ft-long rockfill embankment, an outlet works in the left abutment, and a fish collection facility. The outlet works had an intake tower, two 5.0- by 9.5-ft conduits with a flip bucket, and a water temperature control system for fishery enhancement. The fish facilities were located adjacent to the right side of the plunge pool of the flip bucket. Adult coho salmon and steelhead trout were to be collected and transferred to the Cole Rivers Hatchery at Lost Creek Dam until the runs were transplanted from Elk Creek.

3. Discharge at the site has varied from 0.4 to 19,200 cfs with a mean annual discharge of 238 cfs. The spillway was designed to pass 56,300 cfs at maximum flood control pool elev 1726.** Normal releases would vary from 25 cfs, the minimum release for conservation of aquatic

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* A table of factors for transferring U.S. customary units to metric (SI) units of measurement is shown on page iii.

** All elevations are in feet above mean sea level.

life, to 6,000 cfs, the maximum evacuation discharge. Total design flows through both outlet conduits would be 6,000 cfs at minimum flood control pool elev 1665 and 7,200 cfs at pool elev 1726. A more conservative full pool maximum discharge of 7,500 cfs, based on minimum potential friction factors, was used for the design discharge of the flip bucket and plunge pool.

4. The plan for the fish collection complex (plate 1) at the time of the model study included a regulating outlet flip bucket as a fish barrier, plunge pool, fishway approach channel, auxiliary attraction water channel, fish ladder, collection pool, and water supply. A fish collection system in conjunction with a flip bucket fish barrier was without precedent. The plan was adopted because it would cost about $500,000 less than a conventional downstream barrier and because its use was compatible with mitigation plans for the project.

5. Design of the fish collection system was based on diverting the first 100 cfs of the conduit discharge through the fishway entrance and the next 400 cfs through the auxiliary attraction water channel and leads into the fishway approach. Single-conduit releases greater than 500 cfs would overtop the 35-ft-long catchment overflow weir at elev 1512 and flow directly into the plunge pool. Single-conduit discharges greater than 650 cfs would flip into the plunge pool, and the supply system in the conduit invert would provide only 80 cfs to the fish ladder. Both regulating outlets would be required to supply 100 cfs to the fish ladder entrance with outlet releases above 650 cfs. With dual-conduit releases between 1,300 and 3,650 cfs, one conduit would be operated in the flip mode, and a maximum of about 500 cfs would be supplied to the fish facilities. Approximately 100 to 140 cfs would be provided to the fish facilities when both conduits are operated in the flip mode. According to agreements with fishery agencies, 2,000 cfs was the maximum outlet discharge for which collection of adult fish was necessary. Although the fish ladder would have to be operable for releases to 6,000 cfs to provide a protected location for migrants, velocities over submerged weirs in the ladder would be less than 1 fps at the higher flows.

Need for Model Studies

6. Because of problems with upstream migrant approach conditions in the plunge pool, a hydraulic model was necessary to insure and demonstrate the feasibility of the proposed plan. The objectives of the study were to investigate flow conditions in the plunge pool, location of the fish collection entrance adjacent to the plunge pool, need for a wall between the fish approach channel and plunge pool, and flow conditions downstream from the flip bucket.

The Model

7. The downstream 80 ft of the outlet conduits, the flip bucket, plunge pool, a portion of facilities to supply attraction flow, the proposed fishway entrance and approach, and about 400 ft of downstream channel were reproduced in a 1:40-scale model (photograph 1 and plate 2). Details of the model flip bucket, fishway entrance, and fishway approach channel are shown on plate 3.

8. The conduits and flip bucket were made of acrylic plastic, and elements of the fish collection structures were constructed of sheet metal, waterproofed wood, and plywood. The plunge pool and downstream channel were molded in concrete between metal templates that conformed with prototype surveys and design plans. Separate water supply systems were provided for the regulating conduits, fishway entrance, and auxiliary water supply channel. Discharges from the catchment basin and auxiliary supply withdrawal from the conduit invert were not reproduced.

9. Standard laboratory instruments and procedures were used to measure discharges, water-surface elevations, and wave heights. Computed tailwater elevations (plate 4) were set at a gage approximately 550 ft downstream from the flip bucket and 300 ft from the plunge pool (plate 2). Model measurements were converted to prototype values with equations of similitude based on the Froude model law.

PART II: TEST RESULTS

Fish Attraction Conditions

10. Flow conditions for fish attraction were good in the fishway approach channel and along the right bank of the plunge pool with river discharges of 500 to 950 cfs (plates 5 and 6). However, flow from the plunge pool passed over the upstream weir in the fishway approach wall. That flow might divert some fish from the entrance area to the plunge pool. All the river flow was through the fishway; none spilled directly into the plunge pool.

11. When the river discharge was 1,270 cfs and the left conduit was in the flip mode, upstream flow developed along a section of the right bank, and attraction to the fishway approach was poorly defined (photograph 2 and plate 7). Fish attracted to the plunge area might not find the fishway entrance. When the right conduit was in the flip mode, attraction conditions were good (photograph 2 and plate 8). Similar release conditions with river discharges of 1,500, 2,000, and 3,620 cfs are shown in photographs 3 to 5 and on plates 9 to 15. With those discharges and the left conduit in the flip mode, fish would have to follow an uncertain route along the left side of the plunge pool to the impact area and from there to the downstream end of the fishway approach wall. With the right conduit in the flip mode, attraction conditions were not satisfactory. At a river discharge of 1,500 cfs the principal attraction route would be to the plunge area. At the two higher discharges, attraction would be to the approach channel and to the plunge area with some diverting attraction from the channel to the plunge pool by flow over the approach wall. Flow conditions in the vicinity of the plunging jet during the maximum collection discharge of 2,000 cfs would not be harmful to fish (plate 13). Velocities at the bottom near the plunging jet were 4 to 5 fps. There was no direct impact on the floor. With that discharge, waves were 1 ft high near the structures and 4 ft high just downstream from the plunging jet.

12. Fish attraction conditions were not adequate with a river flow of 6,000 cfs and both conduits in the flip mode (photograph 6 and plate 16).

Upstream flow occurred in the approach channel, and fishway flow was diverted over the upstream end of the approach wall into the plunge pool. Waves were 1.5 to 2.5 ft high near the structures and 7 ft high just downstream from the plunging jet.

13. The proposed fish collection system was not satisfactory because attraction conditions were poor with most operating methods. The fishway approach wall served to direct attraction flow toward the right bank with most conditions, but in many cases flow over the wall was in the wrong direction. Since the plan was not suitable, further study of the need for the wall was not made.

Proposed Revisions

14. A plan with a fishway entrance at the right edge of the plunge area, attraction leads in the base of the bucket structure, and no special approach channel was simulated in the model. Preliminary tests indicated that approach conditions to the entrance should be acceptable with all outlet flows. Fish could approach the entrance along either bank of the plunge pool. Fish near the right bank would be led directly to the entrance; those near the left bank would be led along the face of the bucket structure to it (behind the jet during operation in the flip mode). Scheduled installation of the plan in the model for testing was terminated when design of the project was stopped.

Plunge Pool Length

15. The plunge pool length was correct based on the criteria* of maximum allowable velocities on the runout slope of 10 fps at the top with a discharge of 2,000 cfs and 15 fps at the toe with 7,500 cfs (maximum discharge, full pool elev 1726). With a discharge of 7,500 cfs, velocities at the toe were 4 to 15 fps. In a pool 20 ft shorter average velocities were 12 to 21 fps, and the maximum instantaneous velocity was 24 fps. Velocities with 2,000 cfs were not critical. The model study was terminated before proposed investigations of pool depth and width were made.

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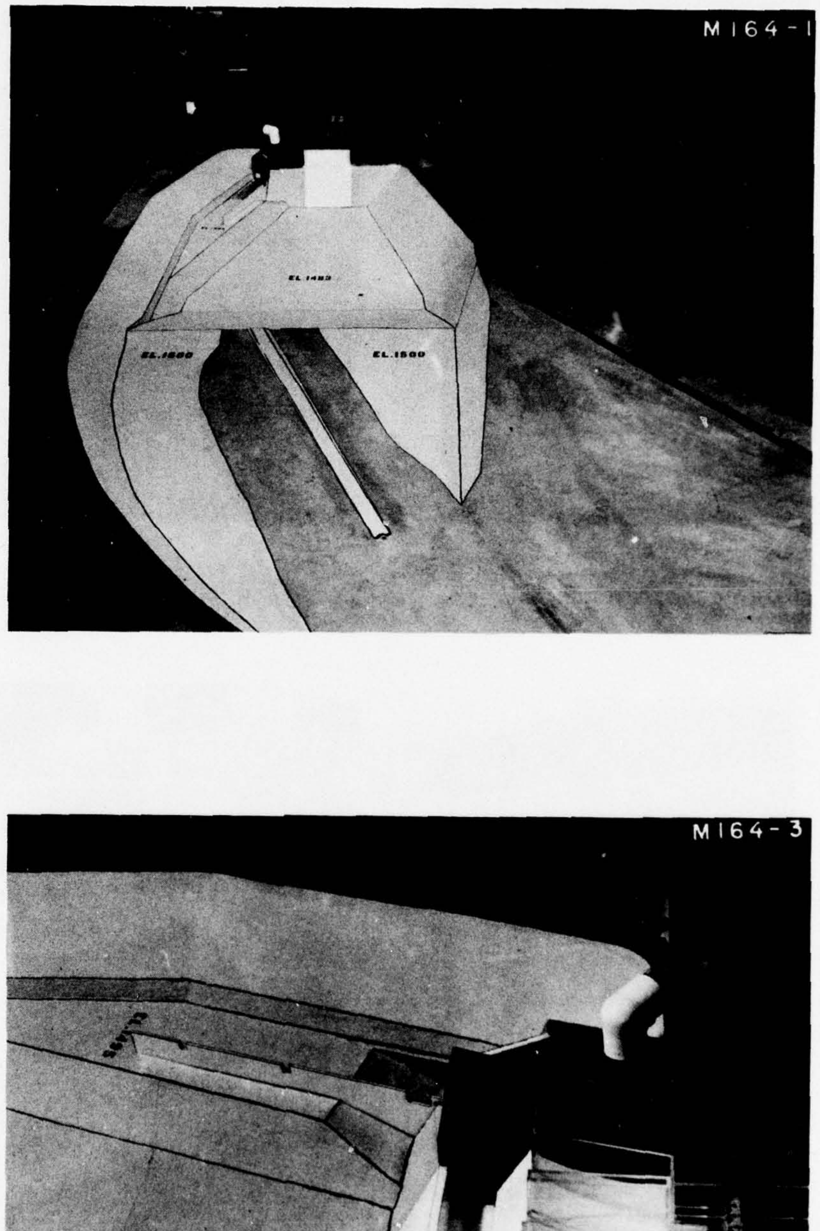
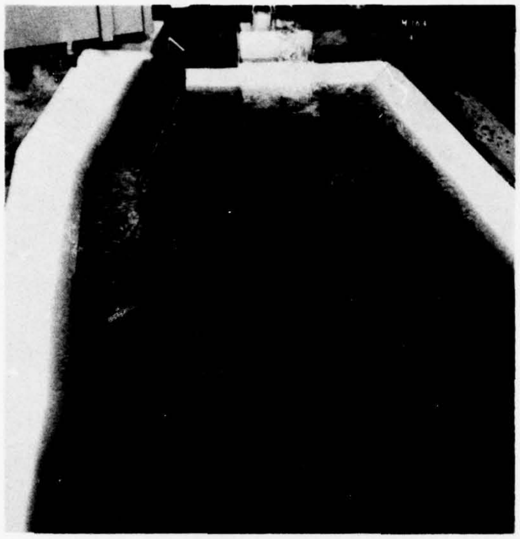
* Established by Portland District on basis of rock conditions at the site.

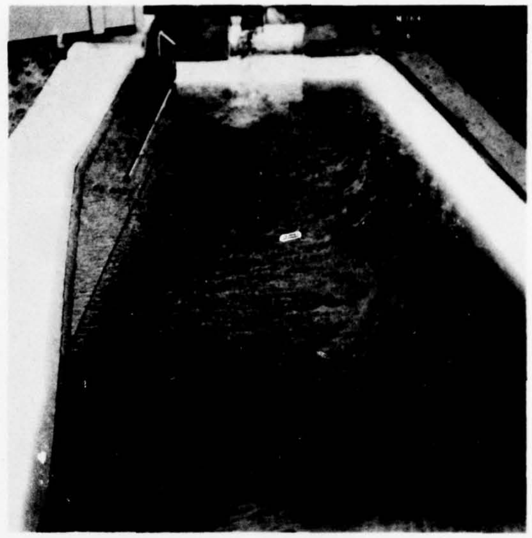
PART III: CONCLUSIONS

16. The flip bucket and plunge pool were satisfactory and would be an effective fish barrier. The original fishway approach channel and entrance on the right bank were not satisfactory. Preliminary tests indicated that a fishway entrance at the right edge of the plunge area and attraction flow leads in the base of the bucket would be effective.



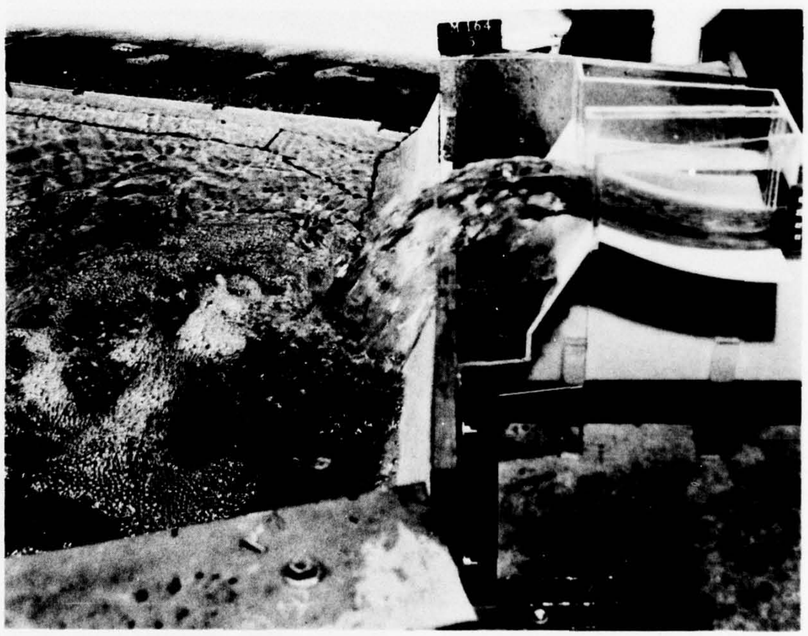
Photograph 1. The 1:40-scale model.





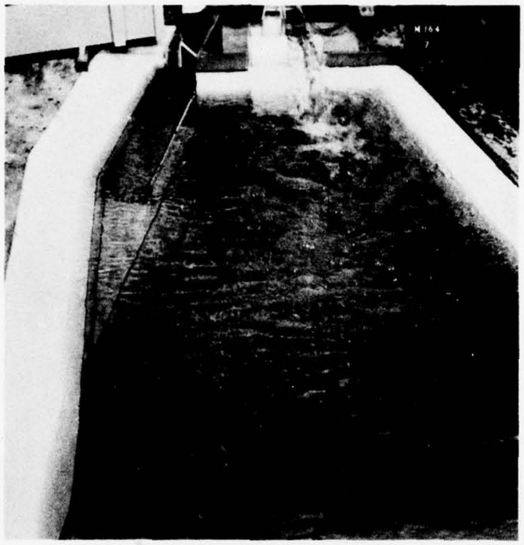
Flow through left conduit

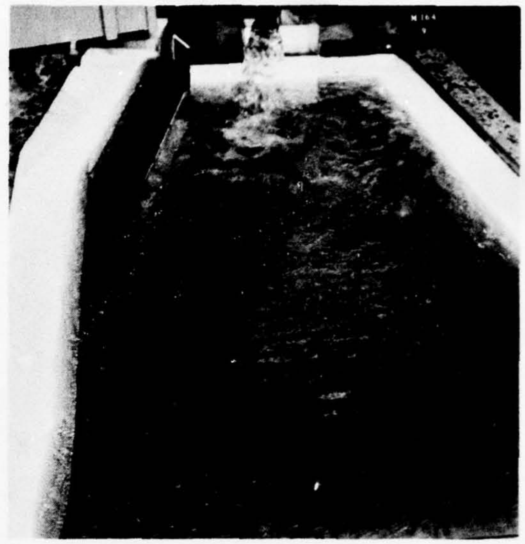
Flow through right conduit



Flow through left conduit

Photograph 2. Flow conditions in plunge pool; river discharge 1,270 cfs, tailwater elev 1503.2, conduit discharge 650 cfs, fishway approach discharge 620 cfs.



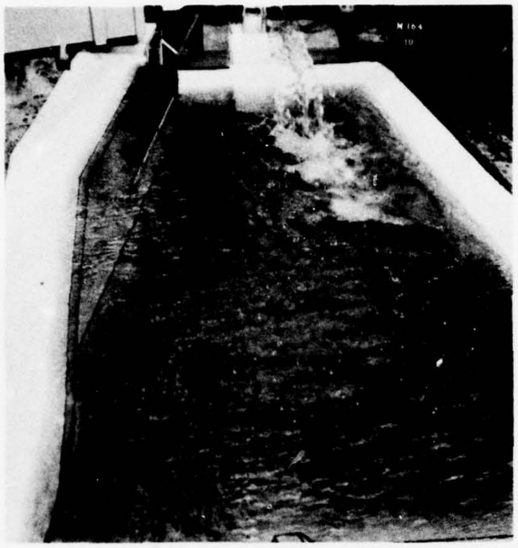


Flow through left conduit

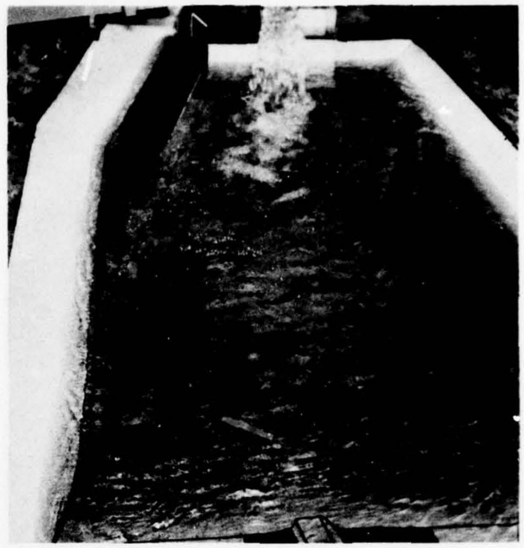
Flow through right conduit

Flow through left conduit

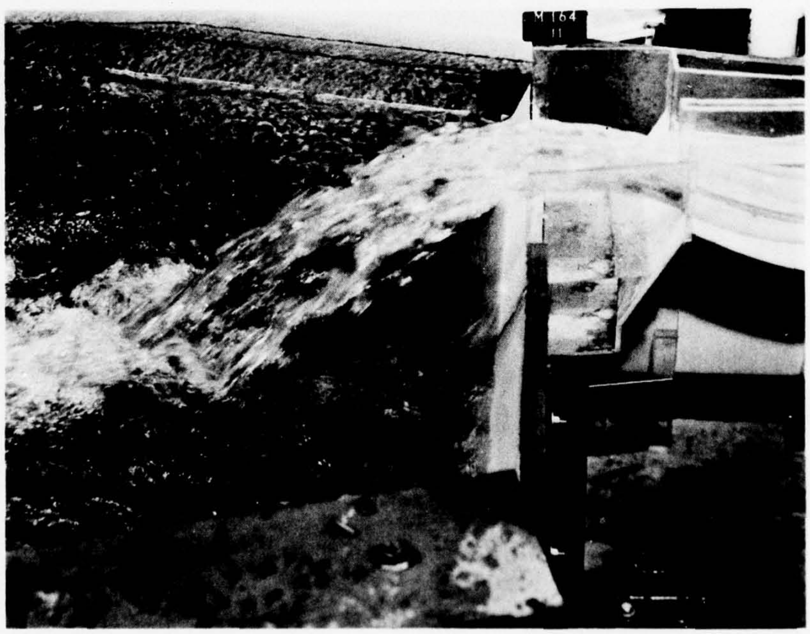
Photograph 3. Flow conditions in plunge pool; river discharge 1,500 cfs, tailwater elev 1503.5, conduit discharge 1,000 cfs, fishway approach discharge 500 cfs.



Flow through left conduit

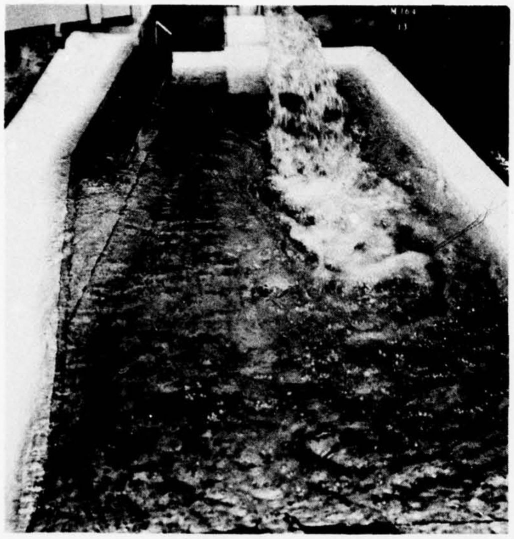


Flow through right conduit

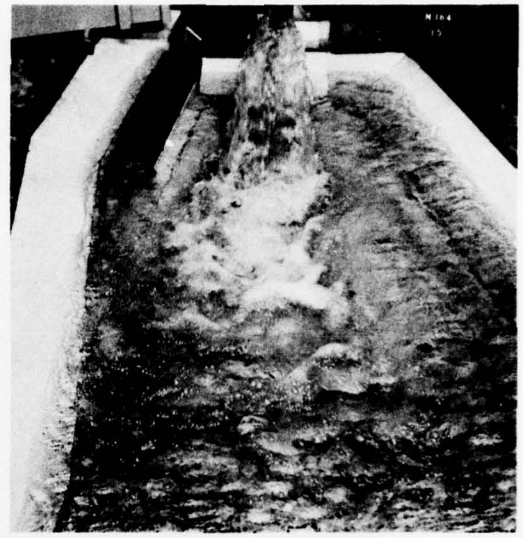


Flow through left conduit

Photograph 4. Flow conditions in plunge pool; river discharge 2,000 cfs, tailwater elev 1504.1, conduit discharge 1,500 cfs, fishway approach discharge 500 cfs.



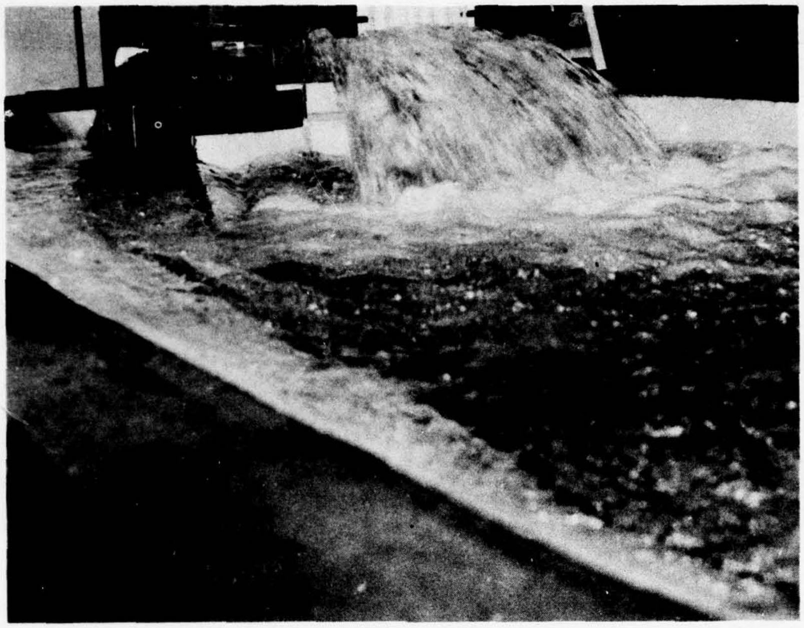
Flow through left conduit



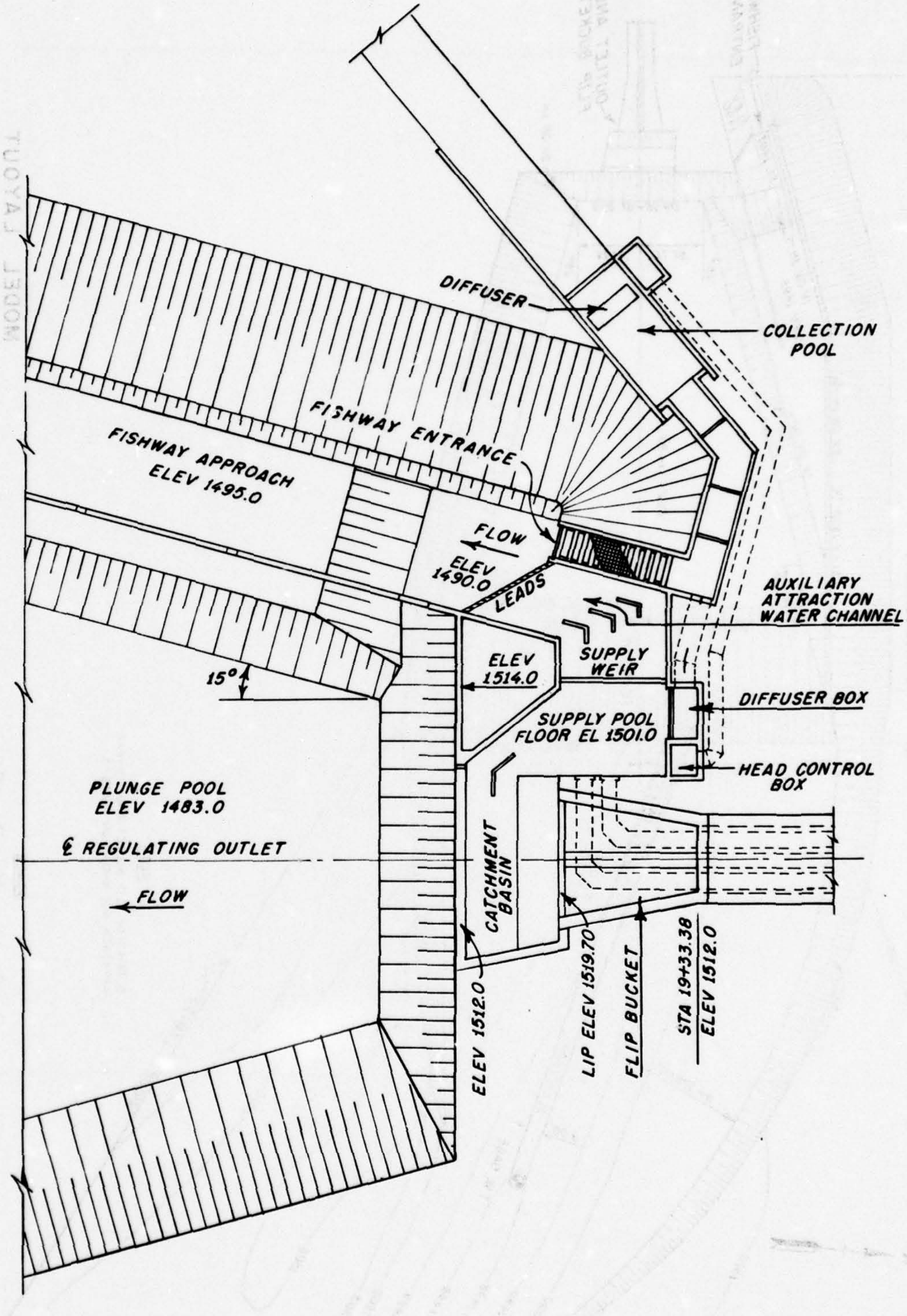
Flow through right conduit

Flow through left conduit

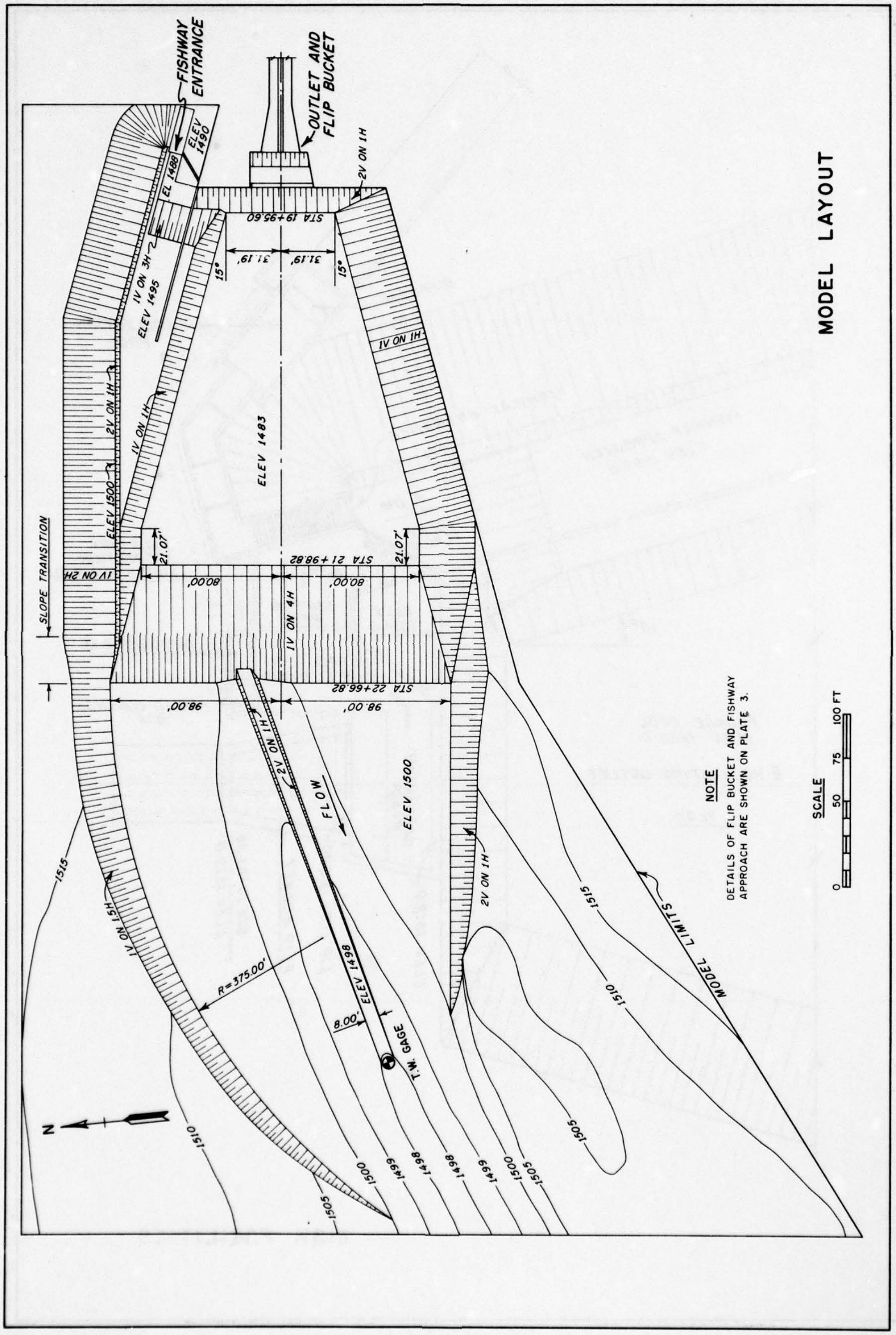
Photograph 5. Flow conditions in plunge pool; river discharge 3,620 cfs, tailwater elev 1505.7, conduit discharge 3,000 cfs, fishway approach discharge 620 cfs.



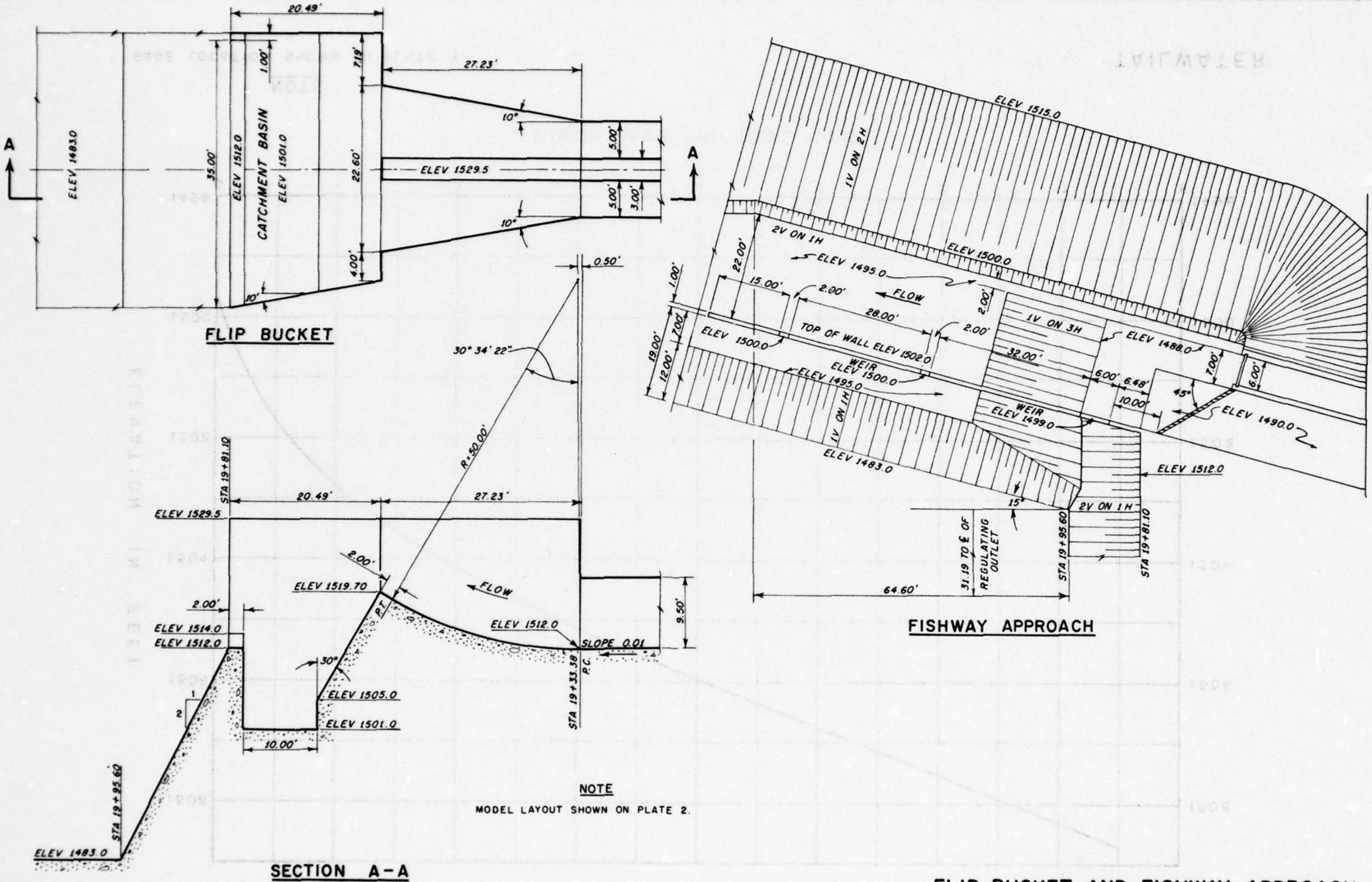
Photograph 6. Flow conditions in plunge pool; river discharge 6,000 cfs, tailwater elev 1507.5, conduit discharge 5,860 cfs, fishway approach discharge 140 cfs.



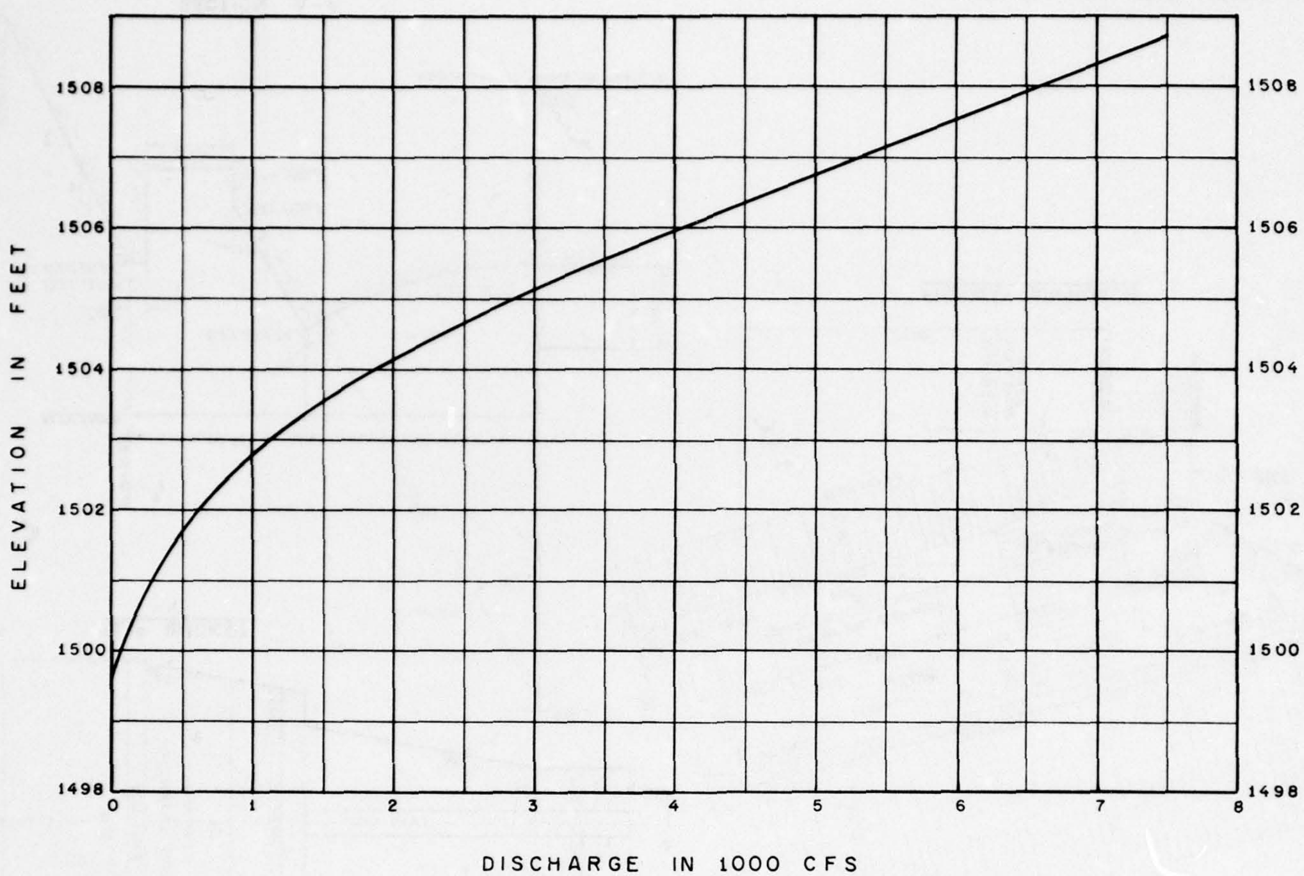
FISH FACILITIES



MODEL LAYOUT



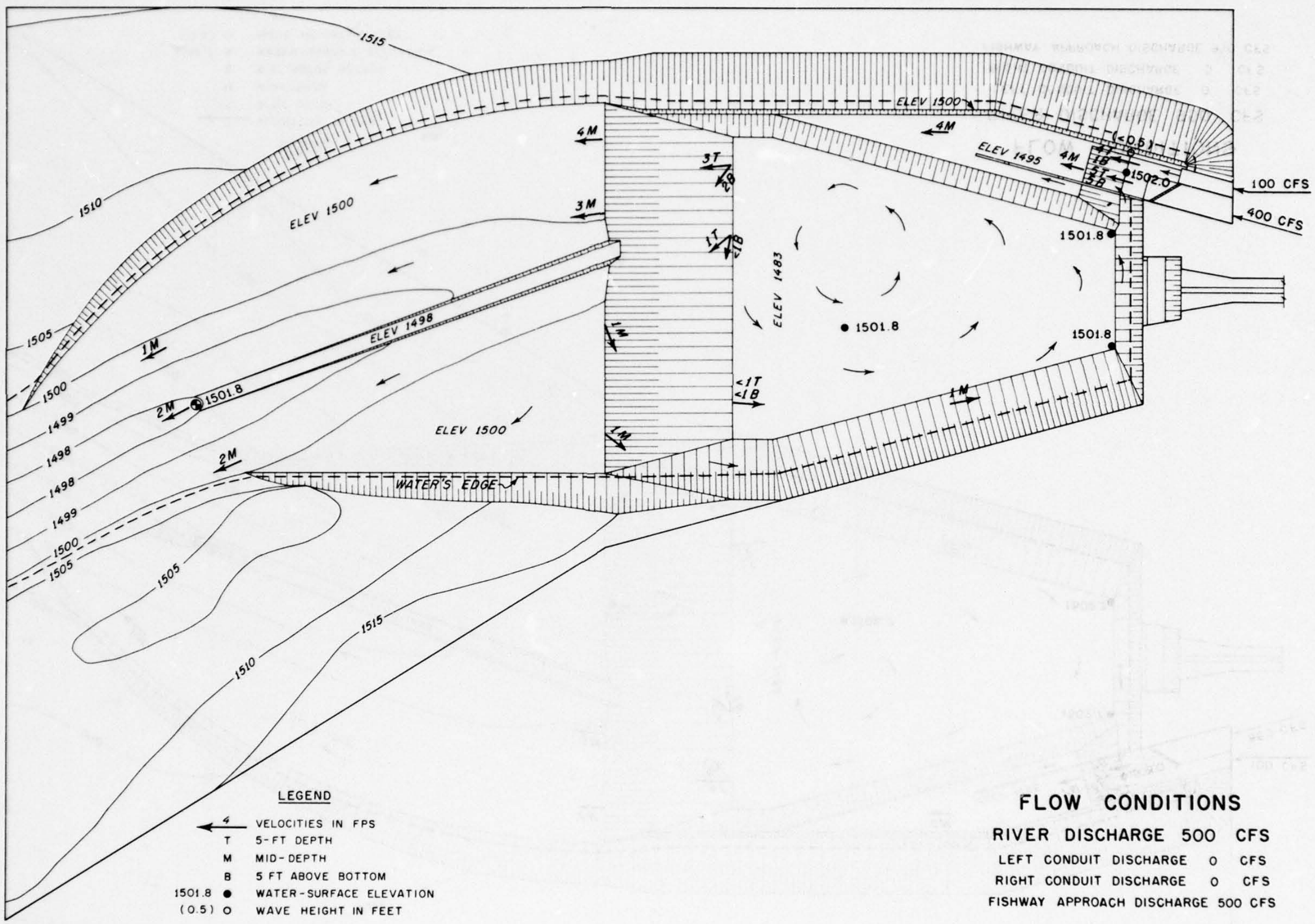
FLIP BUCKET AND FISHWAY APPROACH



NOTE

GAGE LOCATION SHOWN ON PLATE 3.

TAILWATER



LEGEND

4 VELOCITIES IN FPS
T 5-FT DEPTH
M MID-DEPTH
B 5 FT ABOVE BOTTOM
1501.8 ● WATER-SURFACE ELEVATION
(0.5) O WAVE HEIGHT IN FEET

FLOW CONDITIONS

RIVER DISCHARGE 500 CFS

LEFT CONDUIT DISCHARGE 0 CFS
RIGHT CONDUIT DISCHARGE 0 CFS
FISHWAY APPROACH DISCHARGE 500 CFS

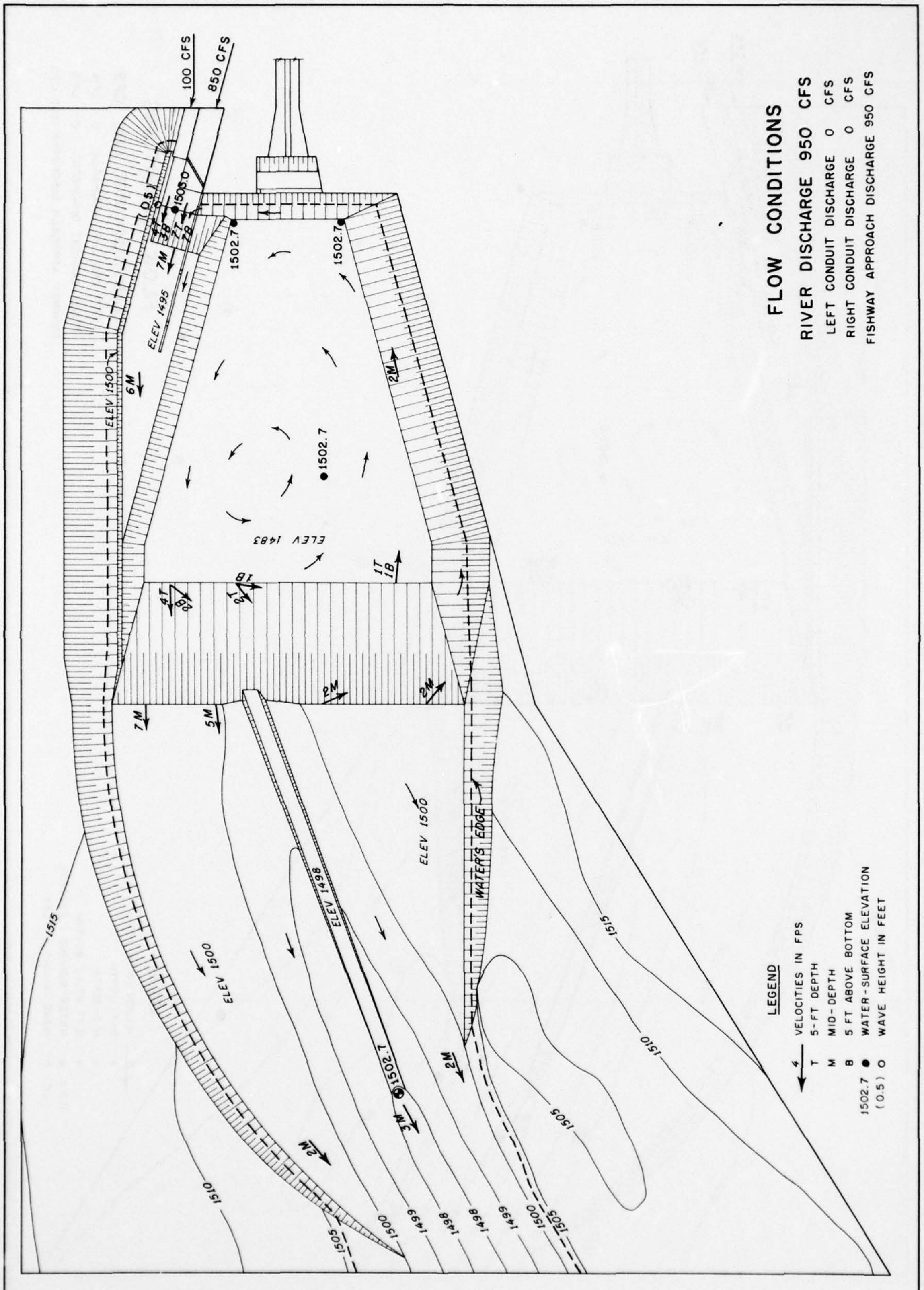
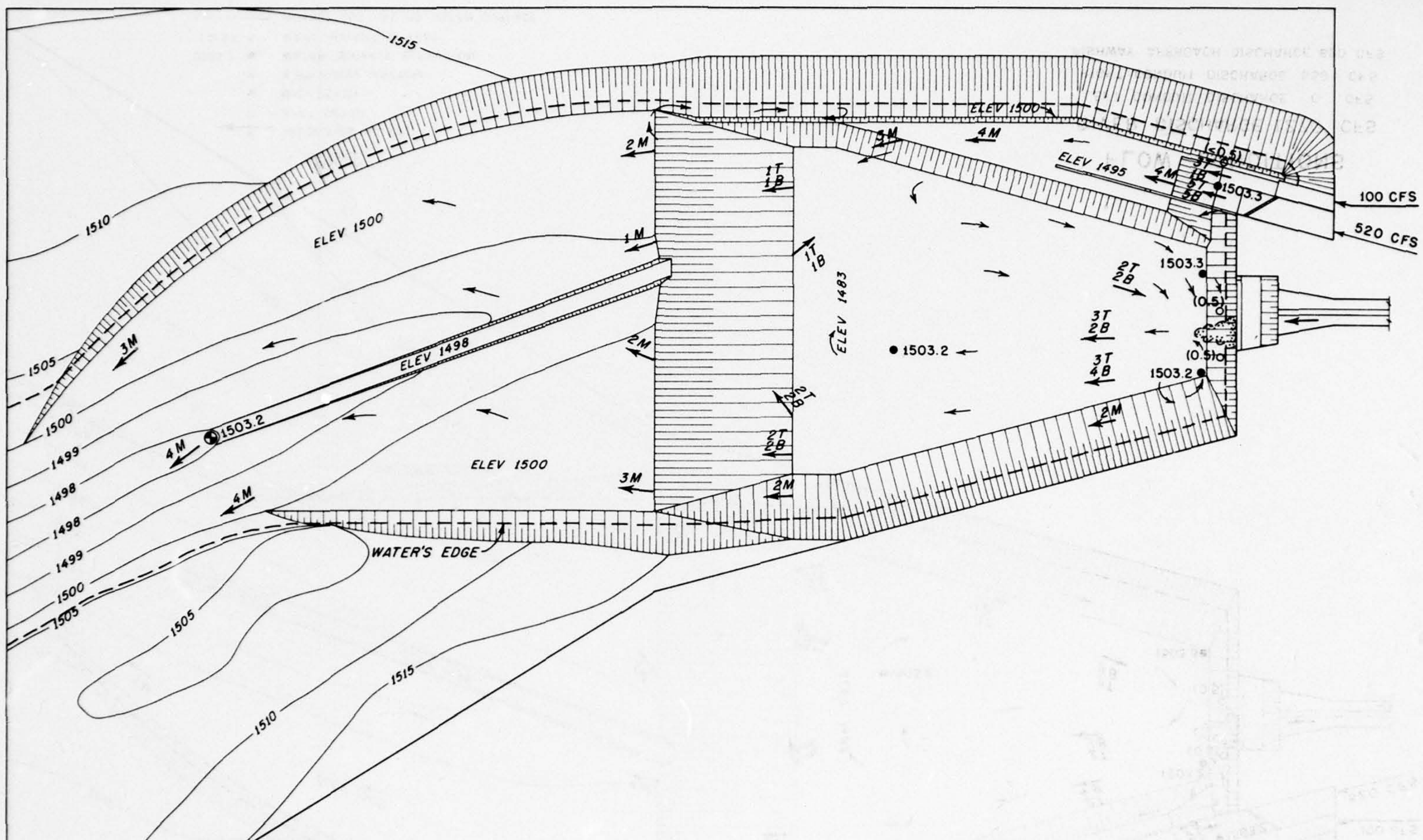

FLOW CONDITIONS
RIVER DISCHARGE 950 CFS
LEFT CONDUIT DISCHARGE 0 CFS
RIGHT CONDUIT DISCHARGE 0 CFS
FISHWAY APPROACH DISCHARGE 950 CFS
LEGEND
4 VELOCITIES IN FPS
T 5-FT DEPTH
M MID-DEPTH
B 5 FT ABOVE BOTTOM
1502.7 ● WATER-SURFACE ELEVATION
(0.5) ○ WAVE HEIGHT IN FEET
100 CFS
850 CFS
ELEV 1495
ELEV 1500
ELEV 1483
ELEV 1498
WATER'S EDGE
1502.7
1505.0
1515
1510
1505
1500
1499
1498

PLATE 6



LEGEND

4 (arrow)	VELOCITIES IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
1503.2 ●	WATER-SURFACE ELEVATION
(0.5) O	WAVE HEIGHT IN FEET
(symbol)	PLUNGE OUTLINE AT WATER SURFACE

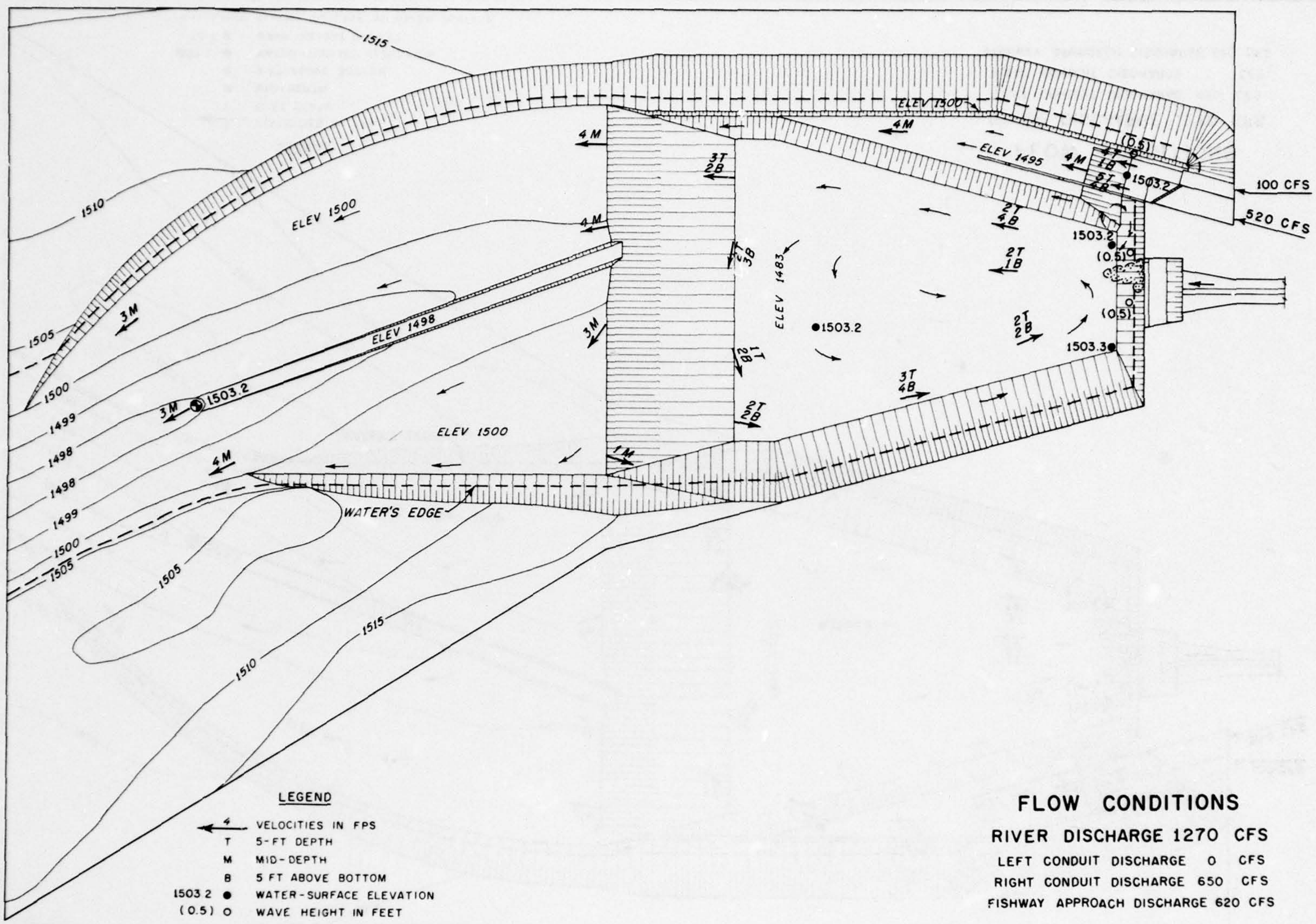
FLOW CONDITIONS

RIVER DISCHARGE 1270 CFS

LEFT CONDUIT DISCHARGE 650 CFS

RIGHT CONDUIT DISCHARGE 0 CFS

FISHWAY APPROACH DISCHARGE 620 CFS



FLOW CONDITIONS

RIVER DISCHARGE 1270 CFS

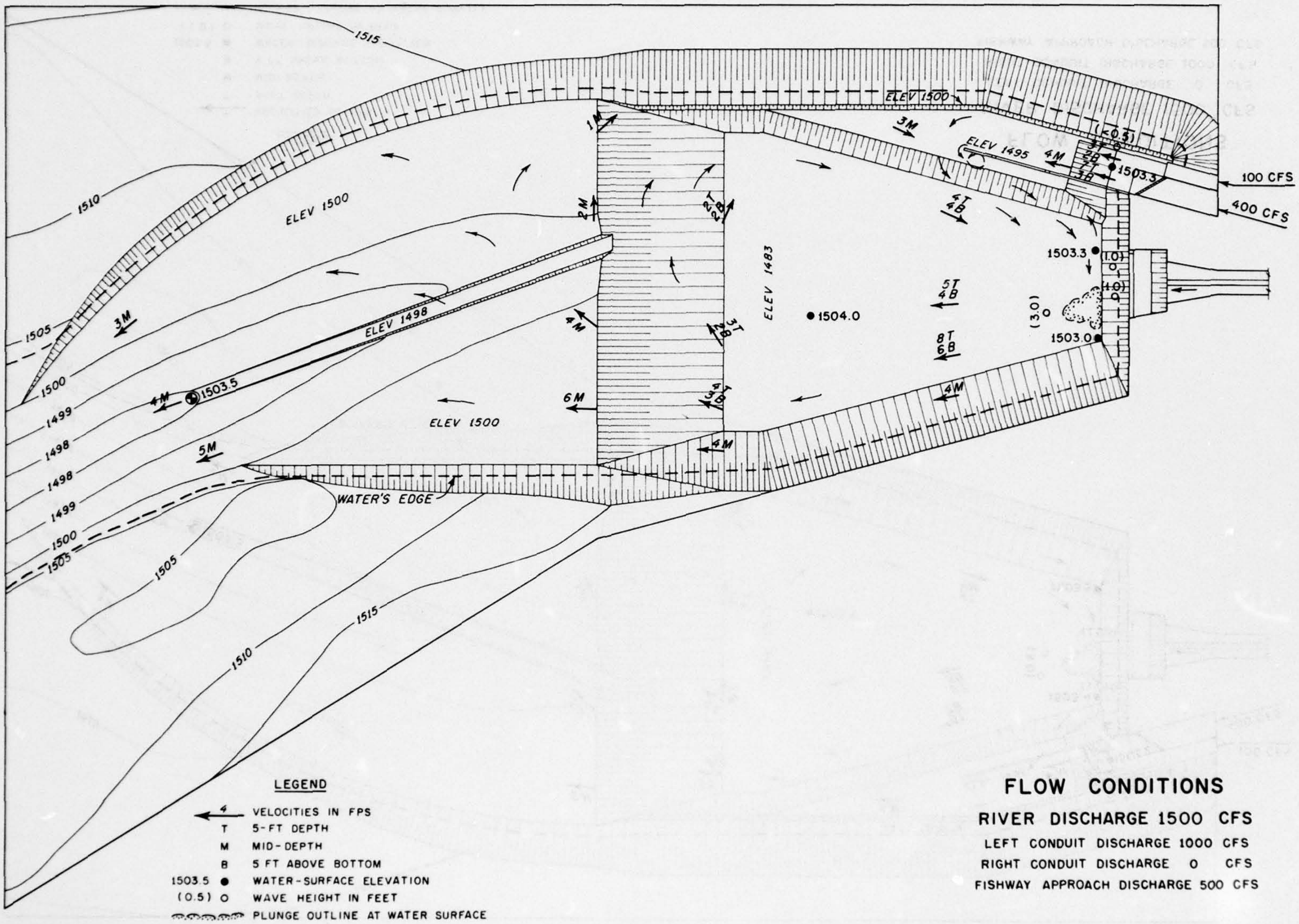
LEFT CONDUIT DISCHARGE 0 CFS

RIGHT CONDUIT DISCHARGE 650 CFS

FISHWAY APPROACH DISCHARGE 620 CFS

LEGEND

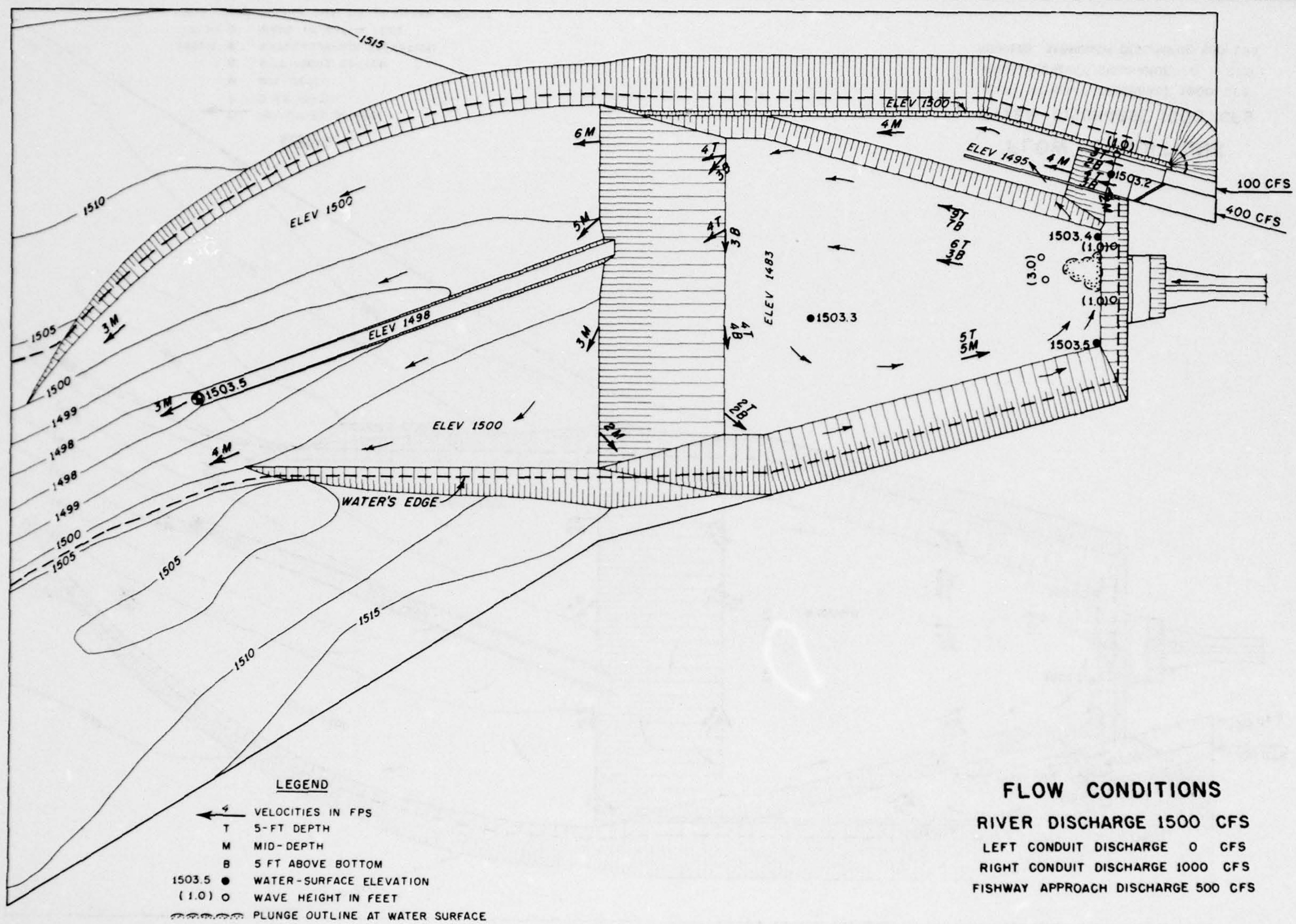
4 (arrow)	VELOCITIES IN FPS
T	5-FT DEPTH
M	MID-DEPTH
B	5 FT ABOVE BOTTOM
1503.2 ●	WATER-SURFACE ELEVATION
(0.5) O	WAVE HEIGHT IN FEET
	PLUNGE OUTLINE AT WATER SURFACE



FLOW CONDITIONS

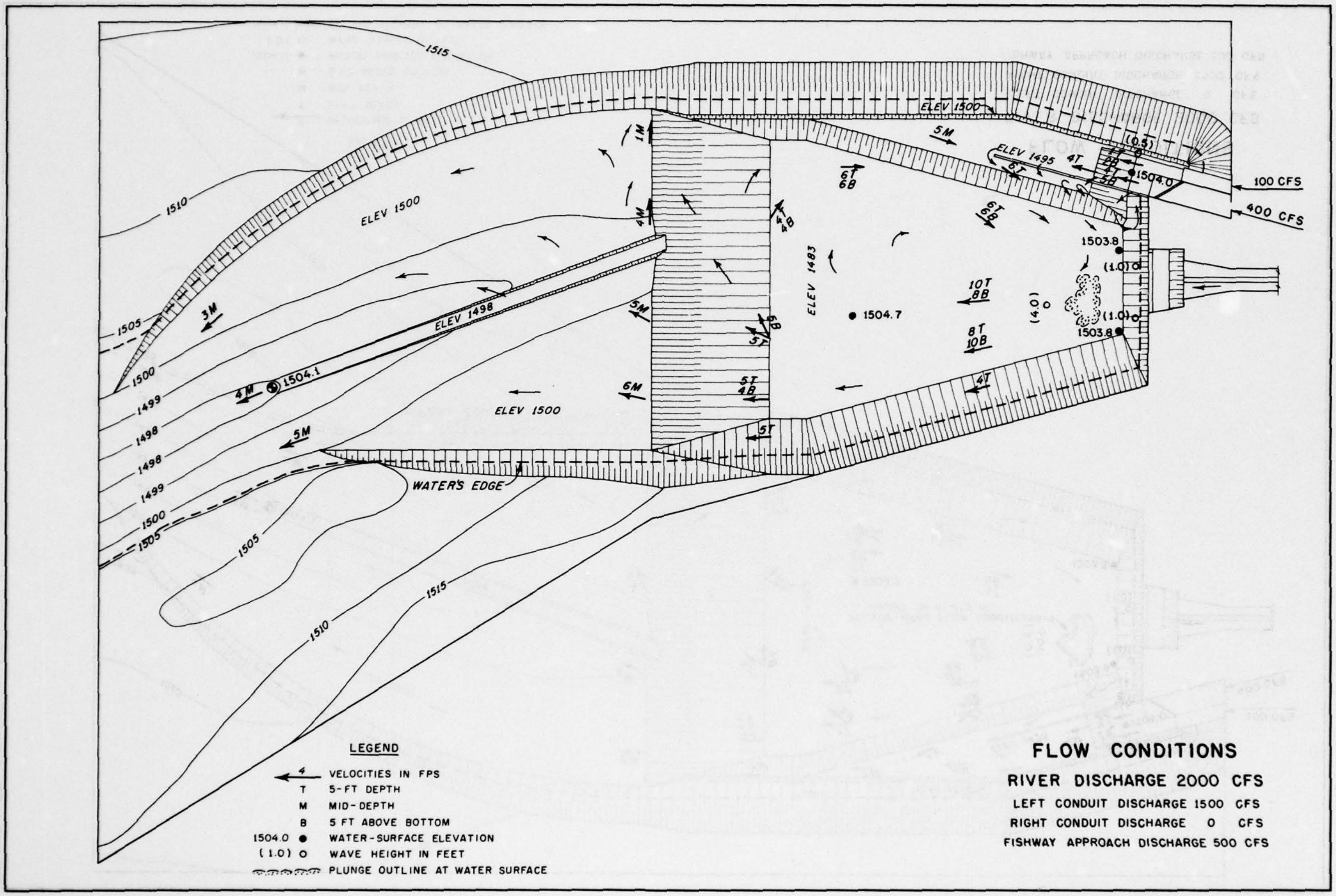
RIVER DISCHARGE 1500 CFS

LEFT CONDUIT DISCHARGE 1000 CFS
RIGHT CONDUIT DISCHARGE 0 CFS
FISHWAY APPROACH DISCHARGE 500 CFS



FLOW CONDITIONS

RIVER DISCHARGE 1500 CFS
LEFT CONDUIT DISCHARGE 0 CFS
RIGHT CONDUIT DISCHARGE 1000 CFS
FISHWAY APPROACH DISCHARGE 500 CFS



FLOW CONDITIONS

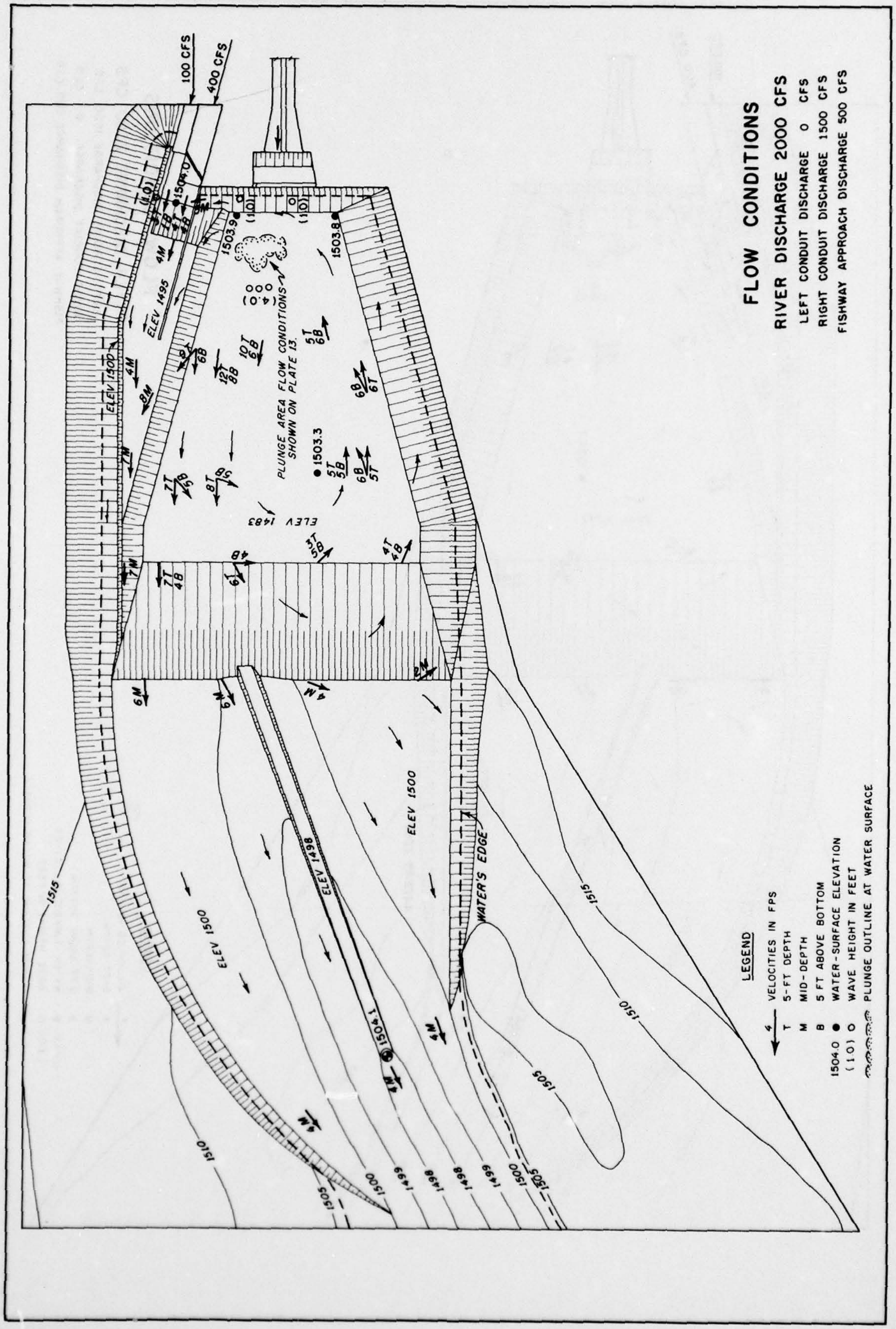
RIVER DISCHARGE 2000 CFS

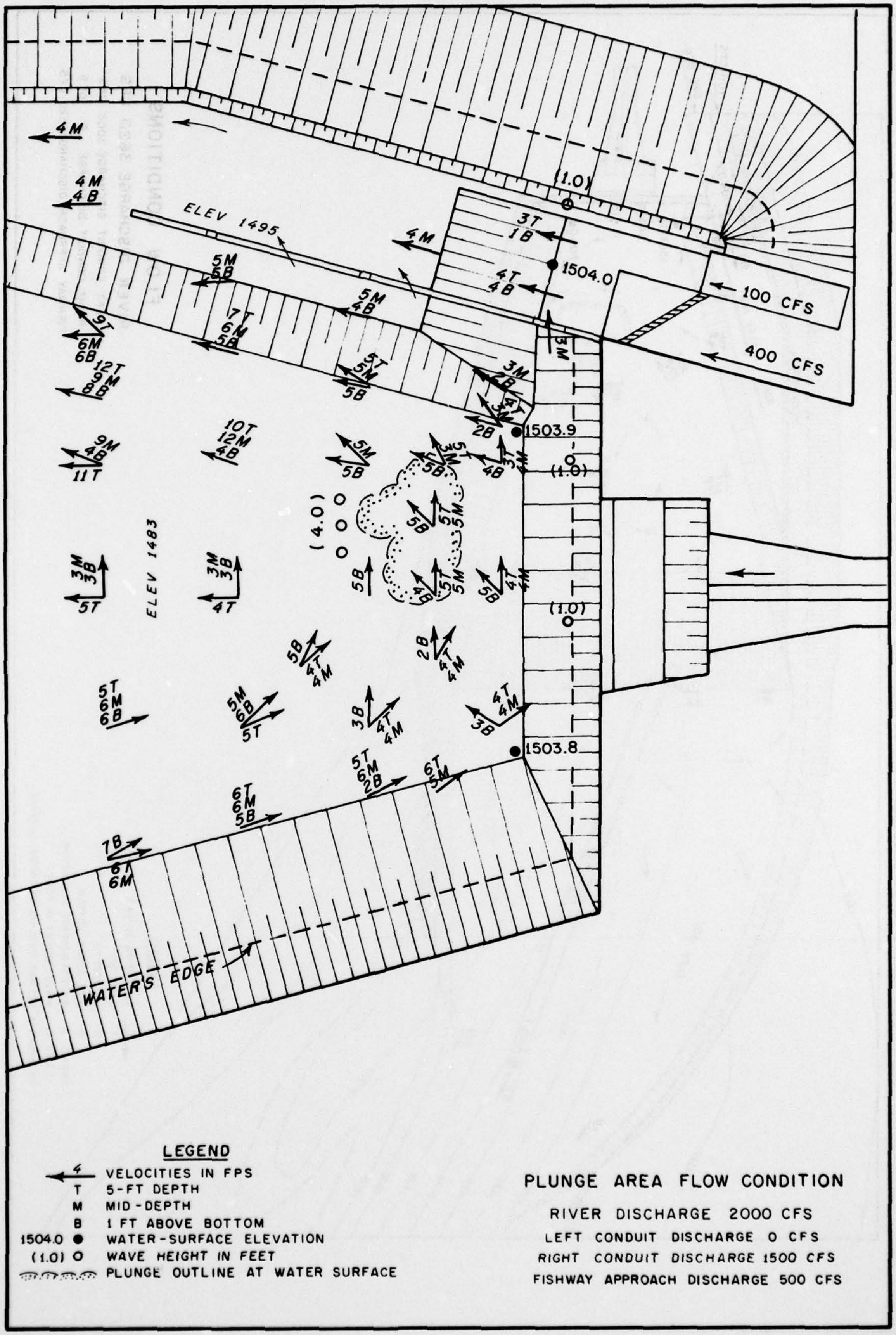
LEFT CONDUIT DISCHARGE 1500 CFS

RIGHT CONDUIT DISCHARGE 0 CFS

FISHWAY APPROACH DISCHARGE 500 CFS

PLATE 11


FLOW CONDITIONS
RIVER DISCHARGE 2000 CFS
LEFT CONDUIT DISCHARGE 0 CFS
RIGHT CONDUIT DISCHARGE 1500 CFS
FISHWAY APPROACH DISCHARGE 500 CFS
LEGEND
VELOCITIES IN FPS
T 5-FT DEPTH
M MID-DEPTH
B 5 FT ABOVE BOTTOM
1504.0 ● WATER-SURFACE ELEVATION
(1.0) O WAVE HEIGHT IN FEET
PLUNGE OUTLINE AT WATER SURFACE
100 CFS
400 CFS
PLUNGE AREA FLOW CONDITIONS SHOWN ON PLATE 13.
ELEV 1495
ELEV 1500
ELEV 1483
ELEV 1498
WATER'S EDGE
1503.9
1503.8
1503.3
1504.1
1515
1510
1505
1500
1499
1498



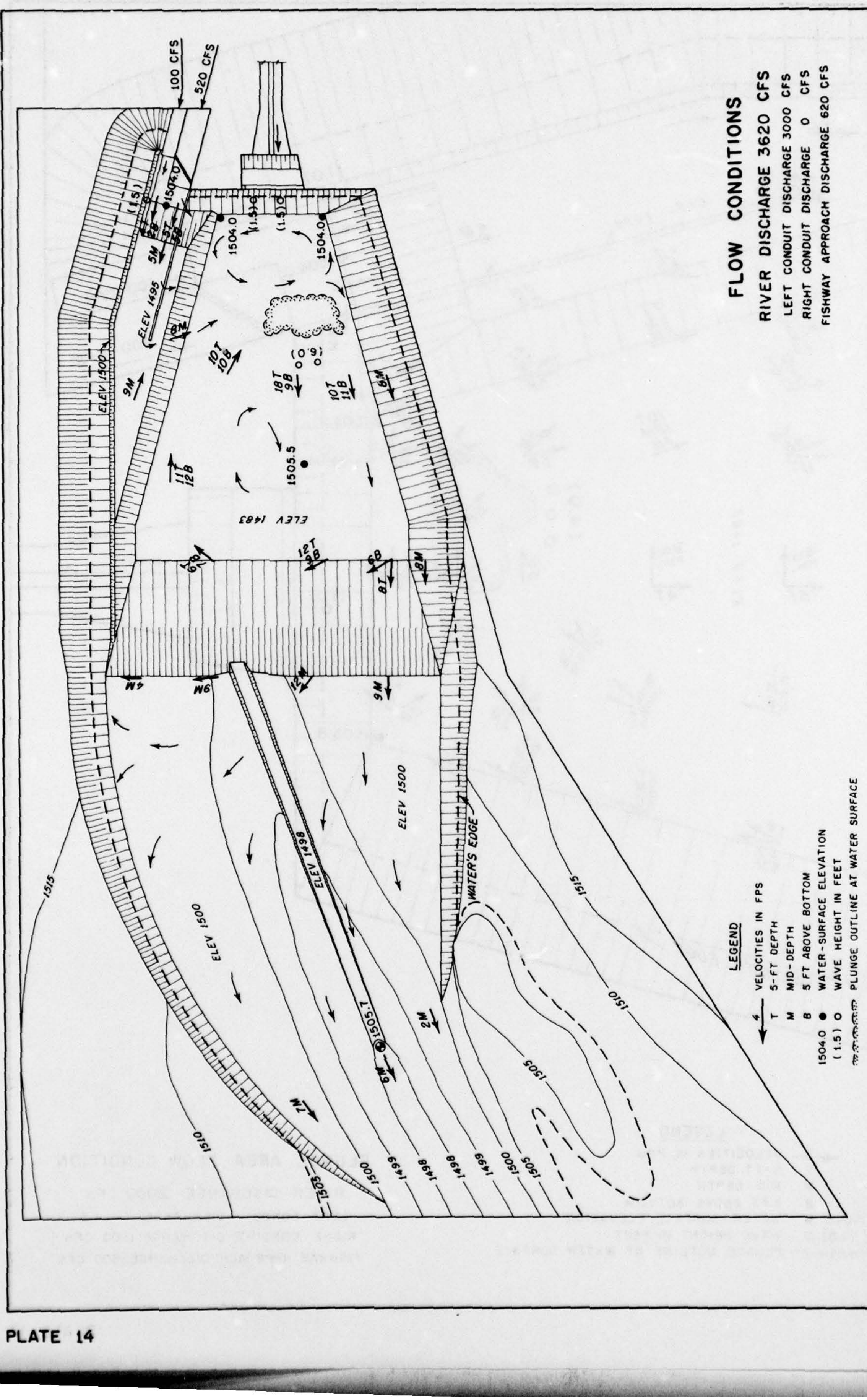
PLUNGE AREA FLOW CONDITION

RIVER DISCHARGE 2000 CFS

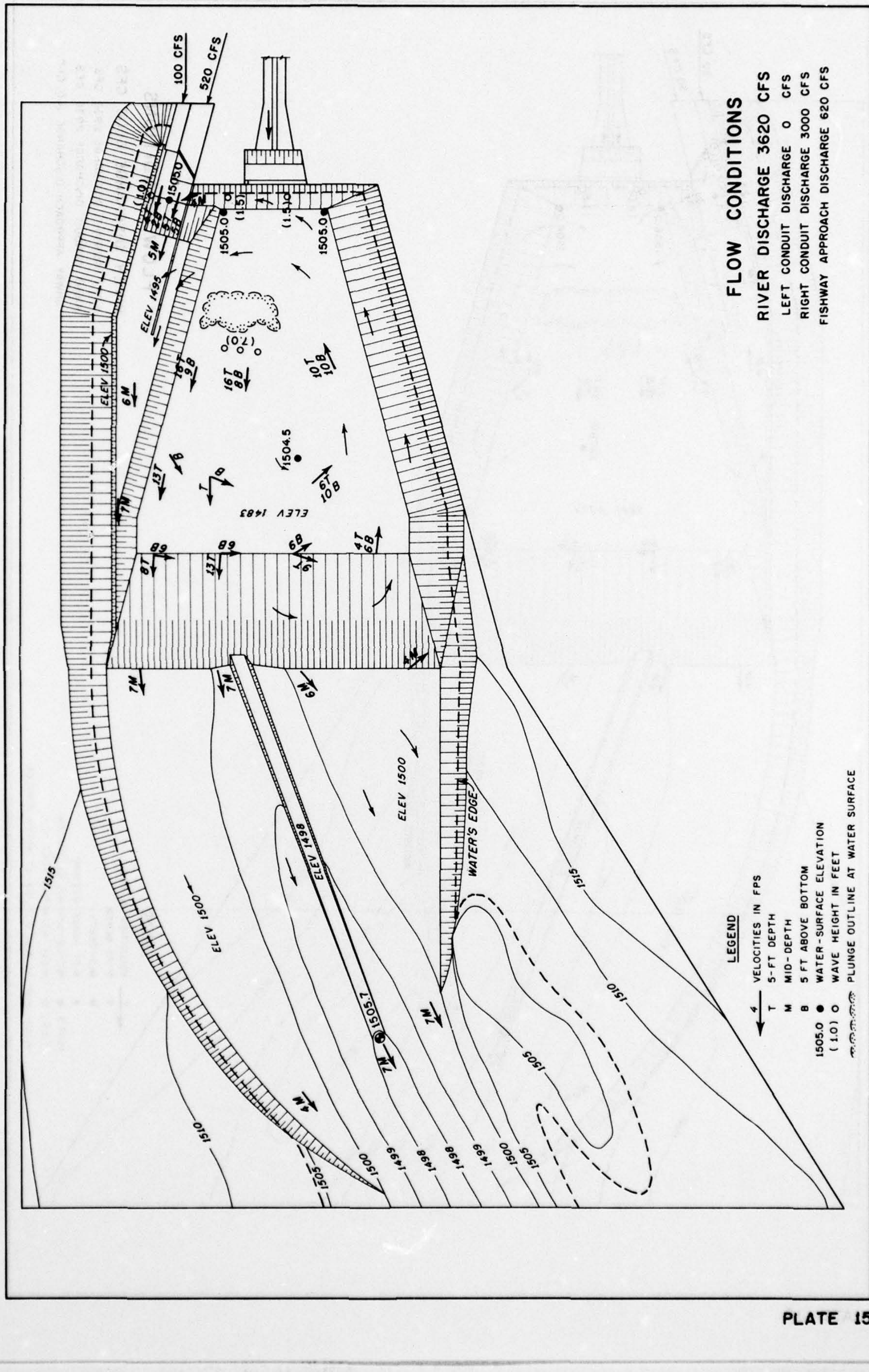
LEFT CONDUIT DISCHARGE 0 CFS

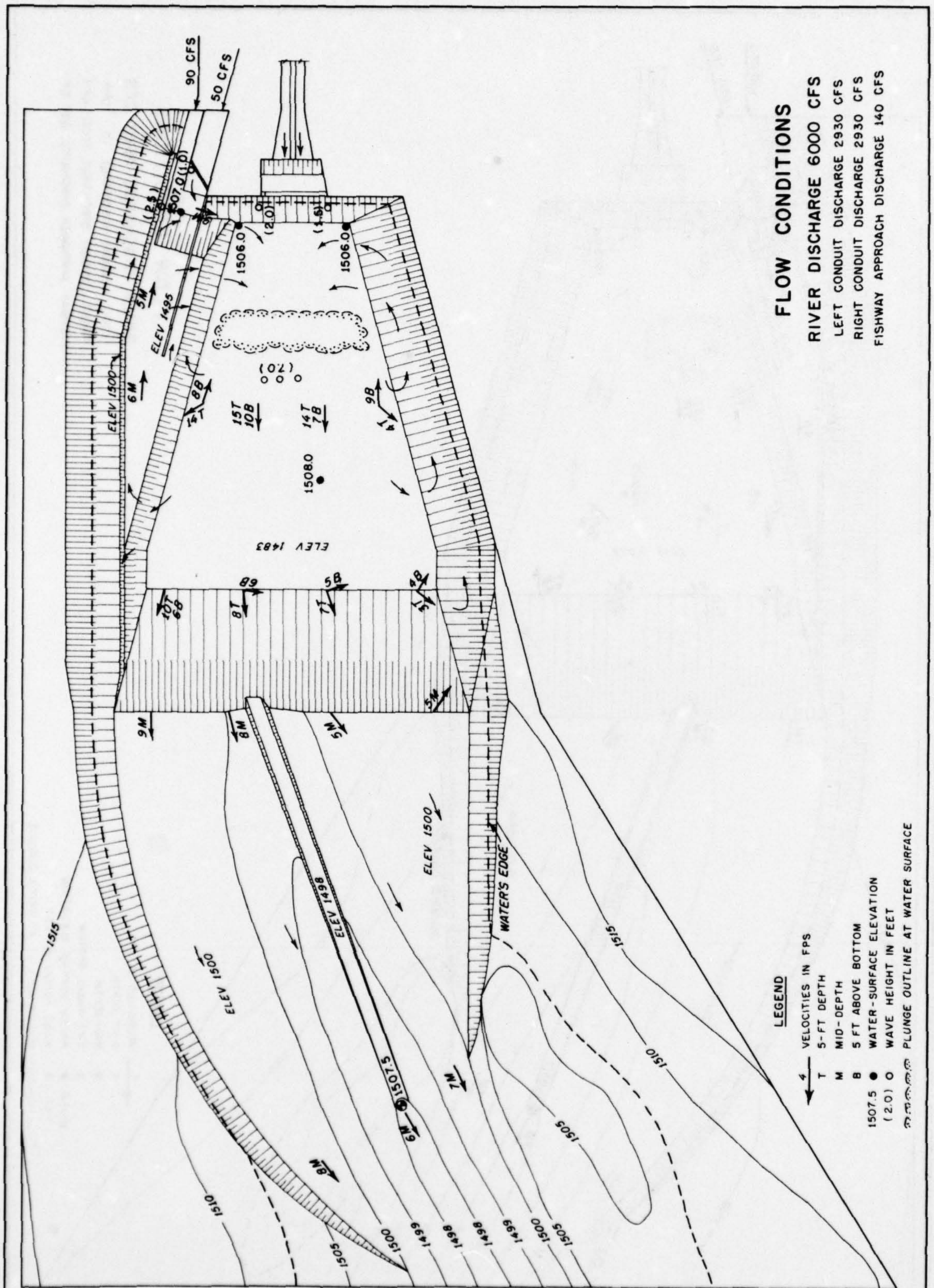
RIGHT CONDUIT DISCHARGE 1500 CFS

FISHWAY APPROACH DISCHARGE 500 CFS



FLOW CONDITIONS
RIVER DISCHARGE 3620 CFS
LEFT CONDUIT DISCHARGE 3000 CFS
RIGHT CONDUIT DISCHARGE 0 CFS
FISHWAY APPROACH DISCHARGE 620 CFS
100 CFS
520 CFS
1504.0
(1.5)
ELEV 1495
ELEV 1500
ELEV 1483
1505.5
ELEV 1498
WATER'S EDGE
1505.7
1515
1510
1505
1500
1499
1498
LEGEND
VELOCITIES IN FPS
T 5-FT DEPTH
M MID-DEPTH
B 5 FT ABOVE BOTTOM
1504.0 ● WATER-SURFACE ELEVATION
(1.5) O WAVE HEIGHT IN FEET
PLUNGE OUTLINE AT WATER SURFACE


FLOW CONDITIONS
RIVER DISCHARGE 3620 CFS
LEFT CONDUIT DISCHARGE 0 CFS
RIGHT CONDUIT DISCHARGE 3000 CFS
FISHWAY APPROACH DISCHARGE 620 CFS
LEGEND
VELOCITIES IN FPS
T 5-FT DEPTH
M MID-DEPTH
B 5 FT ABOVE BOTTOM
1505.0 ● WATER-SURFACE ELEVATION
(1.0) ○ WAVE HEIGHT IN FEET
PLUNGE OUTLINE AT WATER SURFACE
100 CFS
520 CFS
ELEV 1495
ELEV 1500
ELEV 1483
ELEV 1498
WATER'S EDGE
1504.5
1505.0
1505.7
1515
1510
1505
1500
1499
1498


FLOW CONDITIONS
RIVER DISCHARGE 6000 CFS
LEFT CONDUIT DISCHARGE 2930 CFS
RIGHT CONDUIT DISCHARGE 2930 CFS
FISHWAY APPROACH DISCHARGE 140 CFS
90 CFS
50 CFS
1506.0
1506.0
(2.0)
(4.5)
(2.5)
1507.0
(1.0)
(7.0)
15080
ELEV 1483
ELEV 1495
ELEV 1500
ELEV 1498
ELEV 1500
ELEV 1500
WATER'S EDGE
1507.5
1515
1515
1510
1510
1505
1505
1500
1500
1499
1499
1498
1498
LEGEND
4 VELOCITIES IN FPS
T 5-FT DEPTH
M MID-DEPTH
B 5 FT ABOVE BOTTOM
1507.5 WATER-SURFACE ELEVATION
(2.0) WAVE HEIGHT IN FEET
PLUNGE OUTLINE AT WATER SURFACE